IS 3231-2-3 (1987): Electrical relays for power system protection, Part 2: Requirements for principal families, Section 3: General requirements for thermal relays [ETD 35: Power Systems Relays]

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Indian Standard

(Reaffirmed 2001)

SPECIFICATION FOR ELECTRICAL RELAYS FOR POWER SYSTEM PROTECTION

PART 2 REQUIREMENTS FOR PRINCIPAL FAMILIES

Section 3 General Requirements for Thermal Relays

(Second Reprint MARCH 1997)

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BUREAU OF INDIAN STANDARDS
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Indian Standard

SPECIFICATION FOR ELECTRICAL RELAYS FOR POWER SYSTEM PROTECTION

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Section 3 General Requirements for Thermal Relays

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Indian Standard

SPECIFICATION FOR ELECTRICAL RELAYS FOR POWER SYSTEM PROTECTION

PART 2 REQUIREMENTS FOR PRINCIPAL FAMILIES

Section 3 General Requirements for Thermal Relays

0. FOREWORD

0.1 This Indian Standard (Part 2/Sec 3) was adopted by the Bureau of Indian Standards on 26 April 1987, after the draft finalized by Relays Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This standard is one of the series of standards being brought out to cover requirements of protection relays. General introduction to this series is given in IS : 3231 (Part 0)-1986*.

0.3 According to the classification on hierarchical basis [*see* IS : 3231 (Part 0)-1986*], this standard is a second level document.

0.4 This standard is based on IEC Publication 255-8(1978) 'Electrical relays : Part 8 Thermal electrical relays' issued by the International Electrotechnical Commission.

1. SCOPE

1.1 This standard (Part 2/Sec 3) is applicable to dependent specified time electrical measuring relays which protect the equipment from electrical thermal damage by the measurement of the current flowing in the protected equipment.

1.1.1 This standard covers the following two types of relays:

a) Thermal electrical relays having a total memory function of load-current conditions before the conditions which caused the switching of the relays; and

b) Thermal electrical relays having a partial memory function, for example, a memory function of the overload current conditions only.

*Specification for electrical relays for power system protection: Part 0 General ntroduction and list of parts.

1.2 Electrical relays with dependent specified time, having no memory function are not covered by this specification but are covered in IS : 3231 (Part 3/Sec 2)-1987*.

1.3 This standard applies only to relays in new condition.

1.4 Devices (motor starters) covered by IS : 8544 (Parts 1 to 4)† are excluded from this standard.

2. TERMINOLOGY

2.1 For the purpose of this standard, the following definitions in addition to those given in IS : 1885 (Part 9)-1986‡ shall apply.

2.2 Thermal Electrical Relay — A dependent specified time measuring relay which protects an equipment from electrical thermal damage by the measurement of the current flowing in the protected equipment.

2.3 Thermal Electrical Relay with Total Memory Function — A thermal electrical relay which, in its operating characteristics, takes into account the thermal effects of the load and overload currents existing before the operation of the relay.

2.4 Thermal Electrical Relay with Partial Memory Function — A thermal electrical relay which, in its operating characteristics, takes into account the thermal effects of the input currents existing before the operation of the relay only when they exceed a given threshold level which establishes the overload condition.

2.5 Hot Curve – For a thermal electrical relay with a total memory function. the characteristic curve representing the relationship between specified operating time and current, taking account of the thermal effect of a specified steady-state load current before the overload occurs.

2.6 Cold Curve — For a thermal electrical relay, the characteristic curve representing the relationship between specified operating time and current, with the relay in a steady-state condition with a characteristic quantity at zero value.

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*Specification for electrical relays for power system protection: Part 3 Requirements for particular group of relays, Section 2 Dependent specified time measuring relays.

†Specification for motor starters for voltages not exceeding 1 000 V:

Part 1 Direct-on-line ac starters.

Part 2 Star delta starter.

Part 3 Rheostatic rotor starters.

Part 4 Reduced voltage ac starters, two-step auto transformer starters.

‡Electrotechnical vocabulary : Part 9 Electrical relays (*first revision*)

2.7 Correcting Quantity (Compensating Quantity) — A quantity modifying the specified characteristics of the relay in a specified manner. Such quantities can be oil temperature, air temperature, etc.

2.8 Assigned Error — The error limits within which the manufacturer declares that any relay of a given type will perform under the reference conditions.

2.9 Basic Current — The specified limiting value of the current for which the relay is required not to operate.

NOTE — The basic current serves as a reference for the definition of the characteristics of thermal electrical relays. Settings of a thermal electrical relay are made in terms of this current.

3. STANDARD VALUES

3.1 Input Energizing Quantity

3.1.1 *Primary Relays* — No standard rated values for ac or dc are specified.

3.1.2 *Secondary Relays* — The standard rated values of current (rms) for ac are given below:

Preferred values are underlined

$$0{\cdot}5,\ \underline{1},\ 2 \text{ and } \underline{5}\ \text{A}$$

3.1.3 *Shunt Relays* — The standard rated values of voltage are given below:

30, 45, 50, 60, 75, 100, 150, 300 and 600 mV

3.2 Auxiliary Energizing Quantities — The rated values shall be selected from the following standard values, the underlined values being preferred. Other values standardized in particular fields (for example, railways) are permitted.

3.2.1 *AC Voltage (rms)*

$$24,\ 48,\ 55,\ \frac{100}{\sqrt{3}},\ \frac{110}{\sqrt{3}},\ \frac{120}{\sqrt{3}},\ 100,\ \underline{110},\ 115$$

$$127,\ 200,\ 220,\ \frac{415}{\sqrt{3}},\ 380,\ \underline{415},\ 480,\ 500 \text{ and } 660\ \text{V}$$

3.2.2 *DC Voltages*

$$12,\ \underline{24},\ \underline{48},\ 60,\ \underline{110},\ \underline{125},\ \underline{220},\ \underline{250} \text{ and } 440\ \text{V}$$

3.3 Frequency — The standard rated value of frequency shall be selected from the following, the underlined value being preferred:

60, 50 and $16\frac{2}{3}$ Hz

3.4 Contact Circuits — The requirements of contact circuits given in IS : 3231 (Part 1/Sec 1)-1986* shall apply.

3.5 Characteristic Curves — The characteristics of time with respect to current can be stated either by equations or by graphical methods. The equations for a simple thermal model are given in **3.5.1** and **3.5.2**. Other characteristic curves are permitted and should be specified by the manufacturer. As an example, *see* Appendix A.

NOTE 1 — For practical purposes, for example testing, it is convenient to give the characteristic curve as a combination of current and time values. Suitable values may be given by the manufacturer or specified in lower level documents.

NOTE 2 — The time constant used in an equation shall be declared by the manufacturer.

3.5.1 *Cold Curve* — A general curve for thermal electrical relays, based on the heating effect and on the time constant, is given by formula.

$$t = \tau \cdot \log_e \frac{I^2}{I^2 - (k \cdot I_B)^2}$$

where

t = operating time,

τ = time constant,

I_B = basic current (*see* Note 1),

k = constant (*see* Note 2), and

I = relay current.

NOTE 1 — The specified conditions for the basic current (I_B) and relay current (I) are to be stated by the manufacturer. The effective range for which I-curve is valid will be stated in lower level document.

NOTE 2 — k is a constant by which I_B is multiplied to obtain the current value to which the accuracy of the current is referred.

*Specification for electrical relays for power system protection: Part 1 General requirements, Section 1 Contact performance.

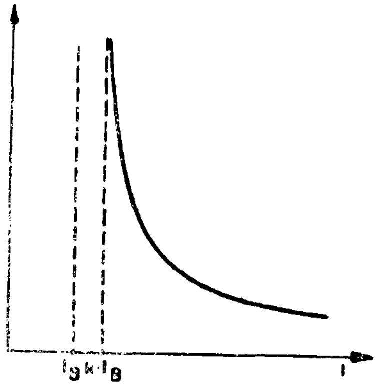

FIG. 1 GENERAL FORM OF COLD CURVE

3.5.2 *Hot Curve* — With regard to preheating on a relay with total memory function, the hot curve is relevant. For example, the equation obtained by modification of the general cold curve is given by the following formula, which is derived in Appendix B:

$$t = T \cdot \log_e \frac{I^2 - I_p^2}{I^2 - (k.I_B)^2}$$

where I_p is the specified load current before the overload occurs.

3.6 Standard Reference Values of Influencing Quantities and Factors, and Standard Values of Their Nominal and Extreme Ranges

3.6.1 *Standard Reference Values of Influencing Quantities and Factors* — The standard reference values and associated test tolerances of influencing quantities and factors are given in Table 1. The reference setting values of time shall be declared by the manufacturer when it differs from maximum setting values. The test tolerances for the setting values of time shall be stated by the manufacturer.

3.6.2 *Standard Values of the Limits of the Nominal Range of Influencing Quantities and Factors* — The standard values of the limits of the nominal range of influencing quantities and factors are given in Table 2.

3.6.3 *Standard Values of Limits of Extreme Ranges of Influencing Quantities or Factors*

a) *Limits of Extreme Range of Temperature* — The standard values of the limits of the extreme range of temperature are −20°C and +60°C.

NOTE 1 — The limits of extreme range of temperature take into account installation, storage and transport conditions. They are applicable only to unenergized relays.

NOTE 2 — Temperature is an example of those influencing quantities which may cause irreversible changes in relays.

TABLE 1 STANDARD REFERENCE CONDITIONS AND TEST TOLERANCES OF INFLUENCING QUANTITIES AND FACTORS

(*Clause* 3.6.1)

	Influencing Quantity and Factor	Reference Condition (*see* Note 1)	Test Tolerances
General	Ambient temperature	27°C	± 2°C
	Atmospheric pressure	86 to 106 kPa (860 to 1 060 mbar)	—
	Relative humidity	45 to 75 percent	(*see* Note 2)
	Position	As stated by the manufacturer	2 degrees in any direction
	External magnetic field	Equal to or less than 10 times the earth's induction (*see* Note 3)	—
	Alternating electro-magnetic field	Zero	Under consideration
	Electro-static field	Zero	do
	Vibration (*see* Note 4)	Zero	do
	Self-heating	(*see* Note 5)	—
Characteristic quantities and input energizing quantity	Basic current	To be given in lower level document	—
	Magnitude (reference for determination of variations)	do	To be given in lower level document
	Frequency	Rated value	± 0·5 percent (*see* Note 6)
	Waveform	Sinusoidal	Distortion factor 2 percent (*see* Notes 7 and 8)
	Alternating component in dc (ripple) (*see* Note 9)	Zero	3 percent (*see* Note 10)
	DC component in ac	Zero	2 percent of peak value
Time	Setting	As declared by the manufacturer	—
	Setting parameter(s) of the curve	As declared by the manufacturer	—

(*Continued*)

TABLE 1 STANDARD REFERENCE CONDITIONS AND TEST TOLERANCES OF INFLUENCING QUANTITIES AND FACTORS — *Contd*

	Influencing Quantity and Factor	Reference Condition (*see* Note 1)	Test Tolerances
Auxiliary energizing quantities	Voltage	Rated value(s)	As declared by the manufacturer
	Frequency	Rated value	± 0·5 percent (*see* Note 6)
	Waveform	Sinusoidal	Distortion factor 2 percent (*see* Notes 7 and 8)
	Alternating component in dc (ripple) (*see* Note 9)	Zero	3 percent (*see* Note 10)
	DC component in ac	Zero	2 percent of peak value

Note 1 — Special conditions of application or the character of the relay may necessitate the use of non-standard values. In such cases, the manufacturer shall state the reference values and tolerances. For instance, special applications may necessitate the use of 45°C as the reference value of ambient temperature instead of 27°C.

Note 2 — During tests of variations due to temperature, this range of relative humidity may be exceeded provided that no condensation occurs.

Note 3 — Conventionally taken as 0·5 mT.

Note 4 — The influence of vibration may be important, in particular for bimetallic relays.

Note 5 — The manufacturer shall declare the effects of self-heating of relays mounted as for normal service and of thermal dissipation by electrical connection where these effects are significant, that is, if they cause changes in accuracy which are of the same order of magnitude or greater than the accuracy class index.

Note 6 — If the performance is independent of the frequency, the tolerance may be larger. When the relay is highly frequency-dependent and high accuracy is required, smaller tolerances may be necessary.

Note 7 — Distortion factor is the ratio between the rms value of the harmonic content obtained by subtracting the fundamental wave from a non-sinusoidal periodic quantity, and the rms value of the non-sinusoidal quantity. It is usually expressed as a percentage.

Note 8 — If the performance is very dependent on the waveform, small tolerances may be necessary.

Note 9 — Alternating component in dc (that is, the ripple content of a dc supply, expressed as a percentage) is given by the following equation:

$$\text{Ripple content} = \frac{\text{Maximum instantaneous voltage} - \text{minimum instantaneous voltage}}{2 \times \text{dc component}} \times 100 \text{ percent}$$

where dc component is the mean value of the waveform.

Note 10 — In certain cases, as agreed by the manufacturer and the user, small tolerances may be necessary.

TABLE 2 STANDARD VALUES OF THE LIMITS OF THE NOMINAL RANGE OF INFLUENCING QUANTITIES AND FACTORS

(*Clause* 3.6.2)

	INFLUENCING QUANTITY OR FACTOR	NOMINAL RANGE
General	Ambient temperature	From − 5 to 45°C (*see* Note 1)
	Rate of change of ambient temperature	To be declared by manufacturer
	Atmospheric pressure	80 to 110 kPa (800 to 1 100 mbar)
	Relative humidity	Neither condensation nor ice formation inside relay case
	Position	5° in any direction from reference position
	External magnetic field	Under consideration. To be stated by the manufacturer, in the meantime
	Alternating electromagnetic field	Under consideration
	Electrostatic field	Under consideration
	Vibration (*see* Note 4 of Table 1)	Under consideration
	Self-heating	*See* Note 5 of Table 1
Characteristic quantities and input energizing quantity	Basic current	Limits of the calibrated range
	Magnitude	Outside the effective range as specified by the mauufacturer
	Frequency	47 to 51 Hz
	Waveform	Under consideration
	AC component in dc; steady state and transient	Under consideration
	DC component in ac, steady state and transient (*see* Note 2)	Under consideration
Time	Setting	Limits of the calibrated range
	Setting parameter(s) of the curve	As indicated by the manufacturer
Auxiliary energizing quantities	Voltage	Under consideration
	Frequency	Under consideration
	Waveform	Under consideration
	AC component in dc; steady state and transient	Under consideration

NOTE 1 — When measuring the effect of different ambient temperatures, sufficient time must elapse to stabilize the relay at the ambient temperature, at which measurements are to be made.

NOTE 2 — The manufacturer should declare the effects due to the transient dc component in the ac, if these are significant.

b) *Limits of Extreme Ranges of the Other Influencing Quantities or Factors*— Extreme ranges of other influencing quantities are not yet included. The extreme ranges which are under consideration concern shock, humidity, etc, especially during transport, storage and installation.

4. VALUES OF LIMITS OF THE OPERATIVE RANGE OF THE AUXILIARY ENERGIZING QUANTITIES

4.1 The limits of the operative range of each auxiliary energizing quantity shall be stated by the manufacturer, corresponding to the duty class of the circuit (*see* **6.1.2**).

4.2 Preferred Ranges — The preferred ranges are 80 to 110 percent and 85 to 110 percent of rated value.

4.3 Marking of the Operative Range

4.3.1 Rated values shall be distinguished from the values of the limits of the operative range(s) by suitable means, for example by underlining or by use of a special type face.

4.3.2 The values may be marked on the relay using, for example, the indications shown in Table 3 (*see* **13**). Clarification, as to which standard range is applicable, shall then be supplied by the manufacturer.

TABLE 3 EXAMPLES OF MARKING THE OPERATIVE RANGE OF AN AUXILIARY ENERGIZING QUANTITY BASED ON 80 TO 110 PERCENT RANGE

	Example	Meaning
A single rated value	<u>110</u>	Rated value, 110
		Operative range, 80 to 110 percent of 110 V
Two rated values	<u>110</u>	Operative ranges, 80 to 110 percent of 110 V for the rated value 110 V
	<u>125</u>	80 to 110 percent of 125 V for the rated value 125 V

5. DUTY CLASSES

5.1 There are two duty classes for thermal electrical relays:

a) Continuous duty, and

b) Short-time duty.

6. THERMAL REQUIREMENTS

6.1 Maximum Permissible Temperatures — The maximum temperatures of insulating materials associated with energizing circuits shall not exceed those permitted for the appropriate class in IS : 1271-1985*, under the conditions given in **6.1.1**.

NOTE — New insulating materials, not yet included in IS : 1271-1985* may be used at other maximum temperatures if the same degree of safety is ensured.

6.1.1 *General Conditions* — For the assessment of maximum temperatures, the general conditions given in **6.1.1.1** to **6.1.1.3**, shall be fulfilled.

6.1.1.1 *Ambient temperature* — The ambient temperature for the purpose of temperature-rise test shall not exceed 45°C.

6.1.1.2 The tests to determine maximum temperatures shall be made with the contact circuits unenergized.

NOTE— The maximum temperatures of materials associated with the energizing circuits are not usually appreciably affected by the current in the contact circuits. In such circumstances, tests of temperature-rise may therefore be made without contact current. When the assembly of the relay or the magnitude of contact currents is such that the temperature-rise of the contact circuits might affect the temperature rise of the energizing circuits, tests should be made with limiting continuous contact current flowing.

6.1.1.3 After the tests, when restored to reference conditions, the relay shall meet all other requirements of the specification.

6.1.2 *Duty Class of Input Energizing Quantity*

a) *Continuous duty* — The relay circuits of this class are energized at the limiting continuous withstand value stated by the manufacturer.

b) *Short-time duty* — The relay circuits of this class are energized at their limiting temporary withstand value. This value and the duration of energization shall be stated by the manufacturer.

6.1.3 *Auxiliary Energizing Quantities* — For the assessment of maximum temperatures, unless otherwise agreed between the manufacturer and the user, the values of auxiliary energizing quantities shall be at the upper limits of their operative ranges (*see* **4**), the relay circuits being energized in accordance with their duty class.

6.1.4 *Settings* — The requirements concerning maximum temperatures apply at all settings.

*Thermal evaluation and classification of electrical insulation (*first revision*).

6.2 Short-Time Overload Tests — The requirements relating to short-time overload tests apply only to input energizing circuits. Test shall be accomplished with all connections made to the relay in the normal manner. After the test and after reference conditions are restored, the relay shall comply with all other requirements of the specification.

6.2.1 *Limiting Short-Time Thermal Withstand Value* — The relay shall withstand a single application of the limiting short-time thermal withstand value stated by the manufacturer for 1 s denoting 1 second (unless otherwise specified).

7. ACCURACY

7.1 General — The accuracy of thermal electrical relays is concerned with the accuracy associated with both specified time and the current. The accuracy class indices relating to operating time and to operating current may be different. Thermal electrical relays may have ranges of adjustment of time and/or current. Accuracy is determined under reference conditions which may specify particular values within these ranges of adjustment (*see* Table 1).

7.1.1 *Declared Performance* — The manufacturer shall declare the assigned error(s) under reference conditions, variations due to influencing quantities, factors, correcting quantities and, where relevant, the effective range of characteristics or input energizing quantities and the consistency.

7.2 Accuracy Relating to Time

7.2.1 *Effective Range of the Operating Current* — The effective range of the operating current will be specified in the appropriate lower level document. The upper and lower limits of the effective range shall be expressed as multiples of the basic current value.

7.2.2 *Assigned Error* — The assigned error shall be either expressed in graphical form within the effective range or expressed by a class index (declared by the manufacturer) which will be multiplied by factors corresponding to the different values of current within its effective range. Corresponding values of current as multiples of basic current and values of assigned errors as multiples of class index will be stated in appropriate lower level documents.

7.2.2.1 The preferred values of class indices are 1·5, 2·5, 5, 7·5, 10 and 20. An example is given in Appendix C.

7.2.3 *Conditions for the Determination of Errors Relating to Specified Time*

a) All tests shall be applied under reference conditions (*see* Table 1);

b) The manufacturer shall, if relevant, declare the previous energizing conditions of the relay, that is, he shall state if thermal equilibrium due to self-heating has to be reached before the beginning of the test; and

c) When the relay includes one or more auxiliary energizing quantities, the manufacturer shall declare if the initial value is rated value or zero.

7.2.4 *Effect of the Influencing Quantities on Specified Time* — The variations due to a single influencing quantity departing from its reference conditions but within the nominal range of use shall be determined with all the other influencing and correcting quantities at their reference conditions.

7.3 Accuracy Relating to the Operating Current

7.3.1 *Assigned Error* — For an electrical thermal relay, the assigned error between the measured operating current value and the value of *K*-times basic current shall be chosen by the manufacturer preferably from the following class indices:

1·5, 2·5, 5, 7·5, 10 and 20

NOTE — However, for certain applications, accuracy class may have to be limited up to 10.

7.3.1.1 An example is given in Appendix C.

7.3.2 *Conditions for the Determination of Errors Associated with the Current* — In addition to those given in **7.2.3**, the following conditions shall also apply:

a) The setting adjustment (if any) to the operating time of the relay shall be at its reference value; and

b) The current shall be increased in steps starting from the quiescent value of the basic current. The current shall be held constant during a time long enough to ensure that the relay has reached its stabilized condition at each step. The step values shall be chosen depending on the accuracy class index of the relay.

7.3.3 *Effect of the Influencing Quantities on the Current* — The variations due to a single influencing quantity departing from its reference conditions but within the nominal range of use shall be determined with all other influencing and correcting quantities at their reference conditions.

7.3.4 *Effect of Correcting Quantities on the Current* — Under consideration.

8. RATED BURDEN

8.1 The value of the rated burden shall be stated by the manufacturer for each energizing circuit under the following conditions:

a) The relay is cold (that is, without previous self-heating);

b) The influencing quantities and factors are under their reference conditions; and

c) The circuit under consideration is energized at the rated value (for auxiliary circuits) or the reference setting of the basic values of the current, all other circuits shall be unenergized unless otherwise declared.

8.2 If the burden is affected by the position of the moving parts, the values corresponding to the operated and initial positions shall be stated together with the minimum and maximum values if they do not correspond to these two positions.

8.3 In addition to the above standard requirements, the manufacturer may also state the burden at other setting values of the characteristic curve.

8.4 The burden shall be expressed in watts for dc circuits and in volt-amperes together with the value of the power factor for ac circuits.

8.4.1 In addition, the manufacturer shall declare sufficient information concerning the burden of the input energizing circuits to enable appropriate voltage and current transformer burden requirements to be defined.

9. MECHANICAL REQUIREMENTS

9.1 The requirements of **9** of IS : 3231 (Part 2/Sec 2)-1987* shall apply.

10. LIMITING DYNAMIC CURRENT

10.1 The relay shall withstand a single application of the limiting dynamic value of the input energizing quantity. The duration of the test should be a half-cycle of sinusoidal waveform at rated frequency.

11. CONSTRUCTION

11.1 The constructional requirements of **10** of IS : 3231 (Part 2/Sec 2)-1987* shall apply.

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*Specification for electrical relays for power system protection: Part 2 Requirements for principal families, Section 2 General requirements for measuring relays.

12. CONTACT PERFORMANCE

12.1 The requirements specified in IS : 3231 (Part 1/Sec 1)-1986* shall apply.

13. MARKING AND DATA

13.1 The following data (with indication of the units, where applicable) shall be made available by the manufacturer:

a) Manufacturers' name or trade-mark;

b) Type designation or serial number;

c) Rated value of the energizing quantity(ies);

d) Values of the limits of the operative range(s) of the auxiliary energizing quantity(ies) (*see* **4.3**);

e) Frequency for ac or the symbol ⎓ for dc;

f) Contact data;

g) Basic current value;

h) Value of constant *k* and current accuracy class index;

j) Characteristic curves and time accuracy class index;

k) Limiting short-time thermal withstand value;

m) Limiting dynamic value;

n) Dielectric test voltage(s);

p) Mechanical durability;

q) Mounting position;

r) Data to permit the suitable connection of the relay, including the polarity;

s) Accessories (if essential to the relay performance);

t) Data concerning the earthing of certain metal parts;

u) Precautions to be taken by the user when replacing parts or modules marked wih the symbol ⚠ and

v) Impulse voltage test data.

13.2 The data (a) and (b) shall be marked on the relay in an indelible manner so that they are legible when the relay is mounted as in service.

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*Specification for electrical relays for power system protection Part: 1 General requirements, Section 1 Contact performance.

The data (c), (e) and (g), if not inferred from (b), shall be marked on or in the relay without necessarily being legible when the relay is mounted as in service.

The symbol ⚠ may be used to indicate parts or modules which should not be replaced without reference to the manufacturer's data [*see* **13.1** (u)].

14. TESTS

14.1 All tests in this standard are type tests, out of which the following shall constitute routine tests:

a) Measurement of assigned error(s) under reference conditions (7), and

b) Dielectric tests [**5** of IS : 3231 (Part 1/Sec 2)-1986*].

14.2 Mechanical Tests — Thermal relays shall be tested for effects of durability and vibration in accordance with **14.1** and **14.2** of IS : 3231 (Part 2/Sec 2)-1987†.

14.3 Insulation Tests — The requirements of IS : 3231 (Part 1/Sec 2)-1986* shall apply.

14.4 High-Frequency Disturbance Tests — This test applies to static relays only. When such a test is applicable, it shall be carried out in accordance with IS : 3231 (Part 1/Sec 3)-1986‡.

*Specification for electrical relays for power system protection: Part 1 General requirements, Section 2 Insulation tests.

†Specification for electrical relays for power system protection: Part 2 Requirements for principal families, Section 2 General requirements for measuring relays.

‡Specification for electrical relays for power system protection: Part 1 General requirements, Section 3 High frequency disturbance test for static relays.

APPENDIX A

(*Clause* 3.5)

CHARACTERISTIC CURVES, COLD CURVES

A-1. Characteristic curves other than the general curve, based on the heating effect and on the time constant (*see* **3.5.1**), are permitted and should be specified by the manufacturer.

For example, by neglecting any heat dissipation because of the short time, the characteristic curve could be based on the equation

$$t = \frac{k_1}{I^2}$$

which is valid for currents higher than the current $k.\ I_B$. This characteristic may be relevant for relays having partial memory function.

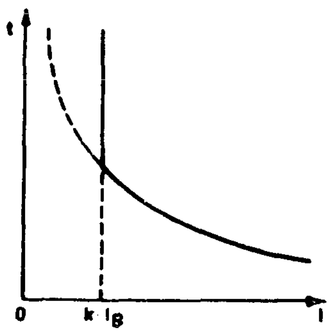

FIG. 2 EXAMPLE OF A COLD CURVE DERIVED BY NEGLECTING HEAT DISSIPATION

APPENDIX B

(*Clause* 3.5.2)

CHARACTERISTIC CURVES, HOT CURVES

B-1. The modification of the general cold curve (*see* **3.5.1**) is obtained by consideration of the temperatures of the thermal analogue.

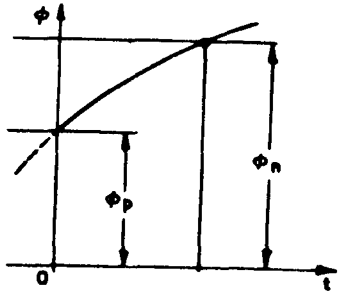

FIG. 3 GENERAL FORM OF HOT CURVE

$$t = \tau . \log_e \left[\frac{\left(\frac{I}{k \,.\, I_B}\right)^2}{\left(\frac{I}{k \,.\, I_B}\right)^2 - 1} \left(1 - \frac{\theta_p}{\theta_n \left(\frac{I}{k \,.\, I_B}\right)^2} \right) \right]$$

where

θ_p = steady-state temperature corresponding to the load current, I_p, preceding the overload;

θ_n = temperature corresponding to $k \,.\, I_B$

$$\text{since} \quad \frac{\theta_p}{\theta_n} = \left(\frac{I_p}{k \,.\, I_B}\right)^2$$

The above equation can be written as:

$$t = \tau \,.\, \log_e \left[\frac{\left(\frac{I}{k \cdot I_B}\right)^2}{\left(\frac{I}{k \cdot I_B}\right)^2 - 1} \left(1 - \frac{I_p^2}{I^2} \right) \right]$$

$$= \tau \,.\, \log_e \frac{I^2 - I_p^2}{I^2 - (k \cdot I_B)^2}$$

B-2. The manufacturer may publish thermal equilibrium curves as in the example given below with the previous load ratio p as parameter:

$$p = \frac{\text{load current preceding the overload } (I_p)}{\text{basic current } (I_B)}$$

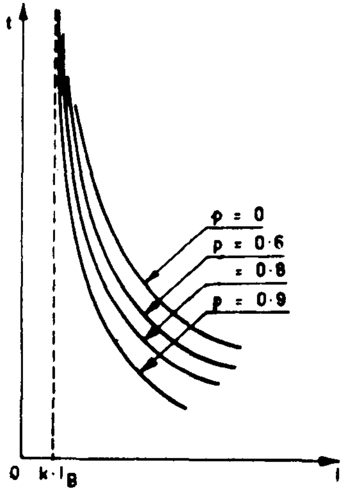

FIG. 4 THERMAL EQUILIBRIUM CURVES FOR VARIOUS VALUES OF p

APPENDIX C

(*Clauses* 7.2.2.1 *and* 7.3.1.1)

EXAMPLES FOR DETERMINING THE ACCURACY

C-1. GENERAL

C-1.1 The class indices related to time and current can be different.

C-2. CLASS INDEX RELATED TO TIME

C-2.1 At $I = n' . I_B$:

Assigned error = Class index
= 5 percent (Example)

C-2.2 At $I = n'' . I_B$:

Assigned error = (Class index) . m''
= (5 percent) . m'' (Example)

C-2.3 At $I = n''' I_B$:

$$\text{Assigned error} = (\text{ Class index }) \cdot m'''$$
$$= (\text{ 5 percent }) \, m''' \qquad (\text{ Example })$$

where

n = multiples of the basic current, and
m = multiples of class index corresponding to n.

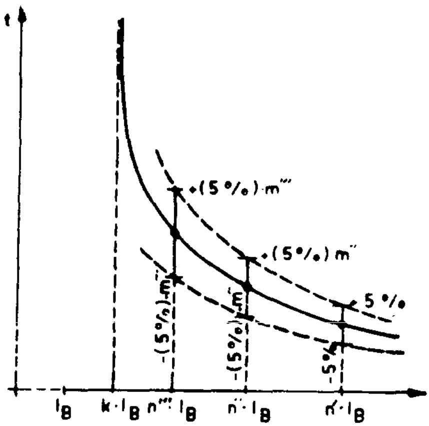

FIG. 5 CLASS INDEX RELATED TO TIME

C-3. CLASS INDEX RELATED TO CURRENT

C-3.1 The assigned error is related to the value of $k \cdot I_B$.

At $t \rightarrow \infty$, assigned error = class index
= 2·5 percent (Example)

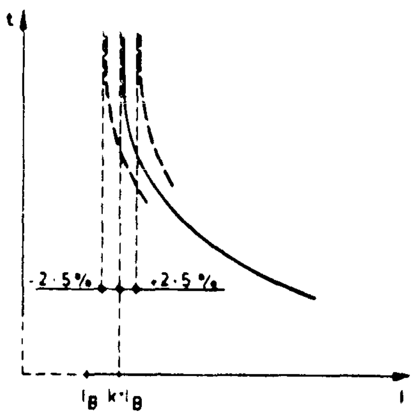

FIG. 6 CLASS INDEX RELATED TO CURRENT

(*Continued from page* 2)

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